with Wills, Legacies and Intestacies ; with the Constitutions, Charters and Statutes of the United States, the State, and of our Cities. With the Laws, Ordinances and Usages of Philadelphia he was especially familiar. His love for his native city was intense, and he was ever ready to devote his time and talents to her service. His zeal continued to the last ; and he was earnest in his efforts that this should be the place of the Centennial Celebration, and that it should be a great success. His patriotism never grew cold or suffered loss from the chill of age ; but he was always young, progressive and ardent for the progress and improvement of the City. The Park, Public Buildings, and wide well-paved streets, and the water supply were objects of his lively sympathy.

The State and United States, their welfare and prosperity, were also very near to his sympathies, and he was ever alive to all that concerned their well-being and safety. This is shown in all the acts of his life, both as citizen and judge. That he lived and labored in the law as he did, and was the able and patriotic citizen that he was, make the name of Chief Justice Read an honor to his family, his City, his State, and Country, and by them all his memory will be held in respect and honor through future time.

The late Chief Justice Read left to survive him, a widow, and his only heir, John Meredith Read, who ably represented our Country, as Consul General to France, and resided in Paris during her fearful investment by the German armies, in 1870 ; and who now again represents our Nation as Minister to Greece.

Chief Justice Read lived and died in the Christian faith ; and was ever an opponent of those false philosophies of France, Germany and Great Britain, and more sparcely of our own Country, which seek to undermine the Christian religion ; that religion which gives to life its greatest consolations, and enables man to triumph over the fears of death ; that religion whose immortal faith, alone, gives adequate meaning to the Universe.

ON THE ALLEGED PARALLELISM OF COAL BEDS.

By Jno. J. Stevenson.

(*Read before the American Philosophical Society, Dec.* 18, 1874.)

That coal seams are approximately parallel, is a common belief among persons residing in the coal fields of our country. The more observing of our coal operatives, however, long ago discovered that the assertion of parallelism is a fallacy, and that the interval between any two given beds of coal is liable to vary many feet in thickness within comparatively short distances. So general is this variation that it amounts to a positive law. Until this was accepted as a fact, to the utter exclusion of any notion of parallelism, the coals of southwestern Pennsylvania remained a worse than Chinese puzzle to Geologists, and

every attempt to tabulate them was a failure. For many years the reports of all observers led us to accept the divergence or convergence of coal seams as part of the necessary arrangement of things, a phenomenon quite as ordinary as the occurrence of sandstone or shale in the intervals.

Quite recently, Prof. E. B. Andrews, an assistant on the Ohio Survey, has re-asserted the parallelism of coal-beds, and admits of such exceptions only, as result from the greater or less compressibility of the materials occupying the intervals. He concedes, it is true, that when large areas of any coal field are examined, it may be found that some portions have had a more rapid subsidence than the rest; but he maintains that as a rule the subsidence was so regular that two seams are found to present an almost perfect parallelism. He doubts whether it is possible for a seam to separate into two or more parts, or if separated, for the parts to diverge indefinitely, that is to say, I suppose, for several miles horizontally or to any great extent vertically.

This is no matter of merely theoretical interest. Involving, as it does, not merely the whole question respecting the deposition of coal seams and the intervening rocks, but also, as a consequence, the identification or tracing of the beds over extensive areas, its exact determination is equally important to the economic investigator and to the purely scientific student. It is true, that the question has been a settled one for many years, but long acceptance of a doctrine does not prove its truth. It has been disputed by a Geologist of standing, whose statements deserve and receive consideration. There is need then, that the matter be presented in such a manner as to leave no doubt in the mind of any that the idea of parallelism over even limited areas is utterly fallacious except for rare localities. In geology an erroneous theory is of necessity a pernicious theory.

Coal seams do divide. That is to say, the numerous partings in a coal bed are liable so to thicken as to become distinct strata of shale or sandstone, and in many cases they do so thicken. In his memoir upon the South Staffordshire Coal Field, Prof. Jukes gives an illustration, especially interesting because of the ease with which the bifurcation of the various seams is proved. The coals begin their separation in the southern portion of the field and the divergence continues northward, the coals never coming together again within the area embraced in the memoir. In Plate 1, Prof. Jukes compares two vertical sections, one taken in the south-central portion of the field, and the other in the north-central portion, the distance between them being about five miles. In the first section, which represents a vertical thickness of 350 feet, there are seven beds of coal, each made up of several distinct layers separated by their partings. In the second section, whose thickness is 850 feet, there are eighteen beds of coal, some simple, but most of them compound. The character of the coal from the several seams in the second section shows at once the relation to the beds of the first section.

To give all the details leading to the conclusion offered by Prof. Jukes, would be impossible here. I therefore present only a few sections, showing the variations of a single bed within a limited area, sections obtained in such proximity to each other, that no possible doubt remains respecting the identity of the coals :

	1	2	3	4	5	6
Flying-reed Coal,.....	4′	4′	4′8″	4′4″	2′6″	3′
Interval, ...	0	10′6″	45′9″	55′4″	118′	128′
Thick Coal,.....	25′4″	25′4″	22′6″	24′3″	24′	22′8″

Further sections* show that the *Thick Coal* finally breaks up into nine beds, the whole occupying, with the intervening rocks, a vertical space of 390 feet. The sections given above show that, within a distance of less than one mile, the interval between the two benches of the seam increases from zero or a very thin parting to 128 feet. The extent of area forbids the supposition that this occurred in a petty lagoon. It is, as I hope to show hereafter, in full accordance with the law of coal deposition in our own country.

Other instances might be cited from Great Britain. Thus Mr. Greenough† states that near Ashby de la Zouche, the *bend*, separating the second and third seam of coal, is in the easternmost coal-pits, thirty-three yards thick ; in the next toward the west, twenty-five ; in the most western, only fourteen ; and that in the Budworth Collieries, half a mile further toward the west, it vanishes entirely, the two seams running together. Another instance is mentioned by Capt. Portlock in his report on Londonderry, etc., pp. 600-601.

In our own country, such marked illustrations though rare, are by no means wanting. The bifurcation of the Mammoth Coal Seam is a well ascertained fact and susceptible of absolute proof. At Mahanoy City, Pennsylvania, one of the most important beds divides, and its branches can be traced for a considerable distance, rapidly diverging. On the Great Kanawha River, in West Virginia, as I have shown‡ the celebrated seam worked at Coalburg, shows this tendency to divide. At the east end of the property of the company these partings are thin, rarely exceeding three inches Followed westward, they increase, until at the western boundary of the property the lower one is two feet thick. About ten miles further down the river, three thin coals are found occupying the horizon of this bed. In all probability, they are simply the subordinate coals, separated by the greatly thickened partings. Cases of distinct division of coals, attended by marked divergence of the benches, must

* For the sections given above, see *The South Staffordshire Coal Field*, by J. Beete Jukes. 2d Edition, 1859, pp. 87 and 38.

† *A Critical Examination of the First Principles on Geology*, by G. B. Greenough. President G. S., &c., 1819, p. 22.

‡ Annals of Lyceum Nat. Hist., Vol. X, p. 276.

remain rare in our coal fields until the workings become more extensive and in closer vicinity than now. At present, it is possible only to show the marked changes in the intervals between our coal beds. In doing this, I shall draw all illustrations from the northern portion of the Great Bituminous Trough, which includes Western Pennsylvania.

Lower Coal Croup.—The total thickness of this group is subject to great variations. In Pennsylvania it is from 270 to 650 feet; in West Virginia from 200 at the Pennsylvania line to nearly 700 in Randolph County, and nearly 900 on the Great Kanawha, in Ohio from to . In each case the Mahoning Sandstone has been omitted. For detailed examination, I choose the two coals known as the Upper Freeport and Kittanning, in Pennsylvania, and as Nos. VI and IV in Ohio.

Along Yellow Creek, in Ohio, the varying interval between these two coals is finely shown in a contiuuous exposure from the Ohio River to Irondale, a distance of seven miles. The coals are known locally as the "Big" aud "Strip" veins, and between them occurs No. V, locally known as the "Roger." I give only four sections for comparison:

	1	2	3	4
Coal VI	7′	3′7″	5′6″	?
Interval Rocks	16′	60′	60′	100
Coal V	3′	?	2′6″	?
Interval Rocks	60′	52′	65′	60
Coal IV	2′6″	?	2′6″	?

These show a variation from 80′ to 160′ within five miles; the most marked change being in the interval between V and VI.

In Guernsey and Muskingum Counties, Ohio, a much more interesting series of changes occur aloug Wills Creek and the Muskingum River. This line of section is an important one, as the coals can be traced almost without break. *Coal IV* is accompanied by its Gray (fossiliferous) Limestone, and VI is everywhere seen in the hills. Beginning on Wills Creek, in Guernsey County, about seven miles north from the Central Ohio Railroad, we find near the Salt Works, the two beds 8 feet apart. Somewhat more than a mile further down the Creek, IV is mined by shaft and is 28 feet below VI. Near Liberty, the interval is 40′; at Bridgeville, 105 feet. Still following the Creek and crossing into Muskingum County, we find the interval at Johnson's Mills, 40 feet; at Frew's Mills, 90 feet; at the Salt Works near the Muskingum River, about the same; near Dresden, about 100 feet, and further down the river 110 feet. The line of least interval seems to run northwestwardly through Guernsey County, from the starting point to a little east from Johnson's Mills, the beds diverging on each side of this line. The structure in a cross section is somewhat as appears in this figure, the upper line representing VI, and the lower IV.

At some distance further, northeastward, a similar relation exists between the coals. Across the intervening space VI can be traced quite

readily, but the exposures of IV are far from being continuous, and for miles it does not reach the surface. It is impossible, therefore, to demonstrate the structure, which seems to be as follows :

What the complete structure of the western portion in the first figure may have been cannot be determined, as erosion has removed all the material beyond the Muskingum River. The direct union of the two beds has not been seen, nor is it likely to be seen, since at all localities where the beds approximate they have a heavy cover.

Crossing into Pennsylvania, we take the same beds and carry the section down to the Ferriferous Limestone. The following sections are taken from Rogers' Report *

Upper Freeport C.	3′	3′	—	5′8″	—	—
Interval Rocks	35′	84′	117′	20′	50′	73′
Lower Freeport C	4′	3′		5′	4′6″	1′6″
Interval Rocks	104′	55′		84′	130′	28′6″
Kittanning C.	3′	3′	3′9″	3′	2′6″	2′
Interval Rocks	25′	30′	33′6″	20′	55′	30′
Ferriferous Limestone	13′	12′	6′6″	8′	6′	8′

In these six sections we find the interval between the two beds varying thus : 184, 143, 142, 117, 109, and 103 feet, while the interval between the Kittaning and the Limestone varies from 55 to 20 feet.

The accessible records of observations in West Virginia are few, but some of them are of interest. In a report upon Property belonging to the Pridevale Iron Company, and situated a few miles above the junction of Cheat and Monongahela Rivers, Prof. W. B. Rogers gives the interval between Upper Freeport and Kittanning, as 160 feet, and between the Kittanning and the Ferriferous Limestone as 50 feet. On Decker's Creek, barely five miles away, I find only 26 feet between the Freeport Coal and the Limestone. The whole group is about 400 feet thick on Cheat river, and only 200 on Decker's Creek. This notable variation occurs chiefly between the upper Freeport Coal and the Limestone, as the section below the latter is substantially the same as both localities.

Going southward, we find the thickness of the whole group rapidly increasing beyond the Baltimore and Ohio Railroad, the Upper Freeport Coal still retaining its proper place under the Mahoning Sandstone, and readily traceable to Randolph County, beyond which I have not followed it. Near the State line at the north, the thickness of the group is 200 feet, in Randolph County it is not far from 700 feet. Whether or not the coal resting on the conglomerate in Randolph County is the same with that resting on the same conglomerate on Decker's Creek, is quite immaterial. It is quite certain that the interval between the conglomerate and the Upper Freeport Coal has increased from 200′ on Decker's Creek, to nearly 700 feet on the Beverly road in Randolph County.

The Upper Freeport Coal itself shows a marked tendency to break up

* Geology of Pennsylvania, Vol. II, Chaps. 18, 19, 20 and 22.

and in Upshur and Randolph Counties it does divide. Its partings thicken up and from mere flimsy plates become layers of shale several feet thick, so that the coal usually only three or four feet thick further north, is gradually converted into a mass of shale and coal upwards of twenty feet thick, which at one locality includes a thin layer of sandstone.

Lower Barren Group.—So interesting is this group in itself, and so irregular are its rocks, that it deserves consideration only because it occupies the interval between the Upper Freeport and Pittsburgh seams, two beds, which seem to be the most persistent of all found in the Coal Measures. It is separated into two divisions by a well marked stratum which in Ohio is known as the *Crinoidal Limestone*, and in Pennsylvania as the *Fossiliferous Limestone*. This I have traced from the Muskingum River round through Pennsylvania into West Virginia, where, like nearly all the Coal Measures Limestones, it disappears in the vicinity of the Baltimore and Ohio Railroad, south from Grafton. At the western exposure of the *Pittsburgh* in Ohio, this limestone is 140 feet below it. Northeastward the interval becomes successively 140, 160, 175, 190, 200, and near Steubenville and along the Ohio River 225 feet. In Pennsylvania on the Monongahela River, it is 320, and near Morgantown, West Virginia, 270. In like manner we find a varying interval between it and the Upper Freeport. At the most western exposure of the limestone this interval is 225, further east 280, at its northerly exposure 260, and at Steubenville, on the Ohio, 280 feet. At Morgantown it is 172 feet.

The total interval between the Pittsburgh and Upper Freeport, varies in thickness in Ohio, from 420 feet at the west, to 505 at Steubenville, the increase being regular toward the east. In Pennsylvania it is 200 feet, at Ligonier, 220 at Elk Lick, and on the Monongahela River from 450 to nearly 600 feet. In West Virginia, along the Monongahela and Tygarts Valley River, it varies not much from 420 feet.

Upper Coal Group.—The following table shows the synonyms of the coals of this group.

Ohio.	*Pennsylvania.*	*West Virginia.*
XIII.	Top at Waynesburg.	Not identified.
XII.	Second Waynesburg.	Brownsville.
XI.	Waynesburg.	Waynesburg.
X.	Uniontown??	Absent.
IX.	Absent.	Absent.
VIII*c*.	Absent.	Absent.
VIII*b*.	Sewickley.	Sewickly.
VIII*a*.	Redstone.	Redstone.
VIII.	Pittsburgh.	Pittsburgh.

In this group the wedge shape of the strata is more distinctly shown than in either of the lower groups, partly because of the persistence of the coal seams and partly because of the long continuous sections which can be obtained over a great extent of country. In it too, there is a

nearer approximation locally to parallelism, while at the same time, the parallelism is apparent rather than real, as the beds converge on each side of the trough. So gradual is this convergence, however, that for all practical purposes most of the beds might be regarded as parallel for short distances.

If we ascend the Central Ohio Railroad from the river to the summit, twenty-two miles west, or better yet, ascend Wheeling Hill, on the National Road, four miles from the river, we count nine well-marked beds of coal, beginning with VIII. If we descend westwardly from the railroad summit or from the National Road on the west side of the Wheeling Creek divide, we find only six beds to and including VIII, the topmost bed in each case being XIII. Let us compare the two sections.

	1	2
1. Sandstone, &c.	50′	50′
2. XIII	1′	1′
3. Shale and Sandstone	70′	70′
4. XII	1′6″	1′3″
5. Sandstone	40′	30′
6. XI	2′6″	2′
7. Sandstone, etc.	98′	100′
8. X	3′	4′+
9. Sandstone	35′–40′	40′
10. IX	2′6″	2′6″
11. Limestone and Calc. Shale	70′	70′
12. VIII*c*	4′	0
13. Sandstone	0–35′	0
14. VIII*b*	0 –6″	0
15. Limestone	20′–30′	0
16. VIII*a*	1′–6″	0
17. Limestone	12′–25′	0
18. Shale	5′–10′	4′
19. VIII	6′	5′
20. Clay and Limestone	10′	8′
21. Sandstone and Limestone	90′	96′
22. Shales, etc.		46′
23. Crinoidal Limestone		4′

The first section is that obtained on the railroad east from the summit. The second, to No. 21 inclusive, was obtained by descending from the summit across the National Road to Stillwater Creek. Nos. 22 and 23 were obtained on the railroad. This section differs from that obtained on the railroad west from the summit, only in Nos. 9 and 11, which are there 60 and 45 feet respectively, the latter being principally sandstone.*

Respecting the identity of No. 19, in both sections there is no dispute. It is beyond all doubt coal VIII, (Pittsburg). Aside from internal evidence furnished by the seam itself, there is abundant stratigraphical proof of identity. I have traced the bed, with the Crinoidal Limestone

* See Annals Lyceum Nat. Hist., Vol. X, p. 232, where I have described the action of the current causing this alteration,

below, all the way round its western and northern out-crop, from the Central Ohio Railroad to Steubenville, on the Ohio River, and thence down the river to Belleair, the initial point of the first section, where it proved to be the No. 19 of that section My identification of No. 8, of the second section with No. 8 of the first has been called in question by Prof. Andrews,* who regards the former as equivalent to No. 12 of the Section I. No. 8, of Section II, is known as the Upper Barnesville Coal, and No. 12, of Section I, is the Glenco Coal. As I take it, *Coal X* at Glenco, is one hundred and ten feet above VIII*c* (Glenco), while at Barnesville it is one hundred and five feet above VIII (Pittsburg). There should be no dispute respecting this matter. It is not so complex as to require much skill for its determination. At Glenco, on the Central Ohio Railroad, nine miles west from Belleair, the coals are shown in the hill as in the section on the margin, and hold the same relations as in Section I. VIII*c* disappears under the railroad about two miles west, and IX at about seven. X and XI remain above the railroad to Belmont, 20 miles from Belleair, where the road rises above X. In the meantime XII is caught by the hills near the railroad. We are now seven miles from Barnesville and the railroad summit intervenes. Ascending to the summit and descending thence to Barnesville, we obtain the following sections.

Coal XI.....	—	
Interval.....	100′	
Coal X.....	—	
Interval.....	40′	
Coal IX.....	—	
Interval.....	70′	
Coal VIII*c*.....	—	

1. Shales and Sandstones in the Summit cut.	50′	
2. Coal XIII, ...	1′	
3. Shale and Sandstone.....	70′	70′
4. Coal XII.....	1′	1′3″
5. Sandstone and some Shale.....	40′	30′
6. Coal XI.....	2′6″	3′+
7. Sandstone, etc.....	98′	100′
8. Coal X.....	3′	4 +

No. 8 in the second section is, the upper coal at Barnesville, and it certainly is the same with No. 8, in the first, which is the one marked X at Glenco, where it clearly lies 110 feet above VIII*c*, the Glenco coal. It is evident then, since X is 110 feet above VIII*c* at Glenco, and 105 feet above VIII at Barnesville, that somewhere between these two points, the strata below No. 11 of Section I, to No. 17 inclusive, of the same section, have disappeared, bringing X about 90 feet nearer to VIII than it is at the river.

But this is not the full extent of this interesting alteration of relations. If, starting from the railroad, we go through Belmont and Jefferson

* See Prof. Andrews' rejoinder to Prof. Newberry, Amer. Journ. Sci., July, 1874.

Counties to the extreme northern exposure of the Pittsburg coal, we obtain a beautiful series of sections fully illustrating the wedge-shape of nearly every stratum between coals VIII and X. In this series *Coal IX* does not appear, as it thins out eastwardly and does not reach the line of section. It is present, however, in the sections, taken four miles west from this line. The localities of the sections are as follows:

1. C. O. R. R. 2. Crossing of Little Short Creek by Wheeling Plank Road. 3. Near Mt. Pleasant. 4. Between Short Creek and Smithfield. 5. Between Smithfield and Little McIntyre Creek. 6. Near Smithfield Station on P. C. & St. L. R. R. 7. Near Knoxville. Of these, the first two are in Belmont County, the rest in Jefferson County.

	I.	II.	III.	IV.	V.	VI.	VI.
1. Coal X	3′	—*	—	—	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
2. Sandstone	40′	50′	—	—	60′	60′	30′
3. Coal IX	0	0	0	0	0	0	0
4. Limestone and Shale	70′	64′	43′	45′	6′	0	0
5. VIII*c*	4′	$1\frac{1}{2}$′	1′	$\frac{1}{2}$′	1′	0	0
6. Sandstone	25	20′	18′	20′	8′	0	0
7. VIII*b*	$\frac{1}{3}$′	0	0	0	0	0	0
8. Limestone	30′	15′	15′	8′	0	0	0
9. VIII*a*	1′	1′	$\frac{2}{3}$′	8″	$\frac{1}{3}$′	0	0
10. Limestone and Shale	25′	30′	$1\frac{1}{2}$	10′	6′	0	0
11. VIII	7′	5′	5′6″	4′9″	$4\frac{1}{2}$	5	4′

The Knoxville section, by Mr. H. Newton, is of further interest in that it shows Coal XI to be only 78 feet above X, whereas, in Belmont County this interval is from 95 to 105 feet. This series shows that the interval between VIII and X, which at the railroad is almost 200 feet, is reduced to only 30 feet at Knoxville, and that the reduction is comparatively gradual, the distance being say thirty miles.

Passing into Pennsylvania I select four sections† from a mass which are equally illustrative, and arrange them, beginning with the most western and going eastward. I take only those showing the relations of the Pittsburg to the Redstone and Sewickly, as the sections containing the higher coals are for the most part imperfect in the lower portion.

1. Interval Rocks	121′+	150′+	30′+	50′
2. Sewickly Coal	6′?	4′	3′	—
3. Interval Rocks	47′	30′	23′	
4. Redstone Coal	—	$1\frac{1}{2}$	3′	0 } 40′
5. Interval Rocks	50′	35′	20′	
6. Pittsburg Coal	$10\frac{1}{2}$	10′	9′	9′

These seem to show a diminution in the thickness of the intervening rocks toward the east. In connection with the fourth section it may be

* In the Sections, a dash signifies that the exposure is such as not to admit of accurate measurement.

† Geology of Penn., Vol. II, pp. 630, 625, 661, and 651.

well to refer to one given on p. 640, lying much further toward the west. In the latter the interval between the Pittsburg and Uniontown coals is said to be 245 feet, while in the former coal is only about 50 feet above the Sewickly and consequently but 90 feet above the Pittsburg.

In West Virginia the conditions are somewhat peculiar. In the narrow Panhandle at the north, IX and X of the Ohio section are absent. They thin out before crossing the Ohio river, VIIIc. is seen on Wheeling Creek, W. Va., but does not reappear on the east side of the trough. Otherwise the Panhandle section offers little of interest and shows no material variation near Wheeling from that obtained just west from Belleair.

In Monongahela Co., near the State line, we find on the east side of the Monongahela R. the following section: Sewickly Coal, 1 ft.; interval, 40 ft.; Redstone Coal, 4 ft.; interval, 60 ft.; Pittsburg Coal, 6 to 8 feet. On the opposite side of the river, and barely three miles away, the section is Sewickly Coal, 5 ft.; interval, 45 ft.; Redstone Coal, 4 ft.; interval, 14 ft.; Pittsburg Coal, lower member, 10 ft. This change results from the disappearance of the heavy sandstone overlying the Pittsburg on the east side of the river.

The limestones of this group disappear somewhat abruptly southward, and give place to shales and sandstones, so that satisfactory sections are by no means frequent. I give for comparison the average sections for Monongahela, Marion Harrison and Upshur Counties:

1. Waynesburg Coal	6′ –9′	3′	5′	Not caught by hills.
2. Interval Rocks	183′–207′		123′	
3. Sewickly Coal	1′ –6′	240′	3′′	
4. Interval Rocks	40′ –49′		41′	20′
5. Redstone Coal	4′ –5′	2′ –3′	2′ –4′	1′ – 2′
6. Interval Rocks	14′ –60′	70′–80′	20′–25′	40′ –60′
7. Pittsburg Coal	6′ –14′	8′ –9′	6′ –9′	3′ 9′′–4′

I feel much hesitation in identifying the Redstone Coal in the last section, and think it much more likely to prove the Sewickly. The difference between the Marion and Harrison sections is very marked, the interval between the Pittsburg and Waynesburg being in one case 320′ and in the other, at most, 190′.

Conclusions.—After a careful study of the barren and upper coal groups throughout the northern portion of the great bituminous trough, I am convinced that as a whole the subsidence was regular, approaching uniformity, but that locally there were bulgings or other irregularities, such as could not fail to accompany any operations so extensive. The lack of parallelism results from the conditions of deposition, which rendered parallelism impossible. The two groups referred to were deposited in a great trough whose eastern boundary was the Alleghany Mountains; the western, the Cincinnati axis.* They diminish quite regularly in thickness, east and west, from a central area between the Ohio and the Monongabela

* The substance of this portion of the paper was published March 4, 1873, in Annals Lyc. Nat. Hist., Vol. X. pp. 247, *et seq.*

rivers. We may compare each group to an enormous bowl, somewhat elongate and with flattened base.

At the beginning of the upper coal era this trough was a great arm of the sea, closely land locked and communicating with the ocean at the southwest by a comparatively narrow outlet. On the east and southeast sides, rivers brought in their loads of detritus from the highlands to be spread over the bottom, which gradually declined toward the west and northwest. On the opposite shores few streams flowed out, and such as came were sluggish, bearing no coarse material. The place of quiet, pure water is marked by deposit of limestone in the north, while a similar mass, traceable through Ohio southwestwardly, marks the direction of the outlet. The low shore of the southeast is marked by the shallow water detrital deposits and the utter absence of limestones in West Virginia, south from the N. W. Branch of the Baltimore and Ohio Railroad.

The wedge-shape of the rocks intervening between the coals of this group has been shown both in Pennsylvania and Ohio, east and west, as well as in West Virginia, where the tapering is southeastward toward that edge of the trough. The structure of the trough may be illustrated as follows :

Let a basin with gently sloping sides be lined with some black substance ; then filled with some material which will become hard, in which a similar black substance is arranged in layers, some of them covering the whole surface, and others extending only part of the way from the border toward the middle. Now break away the bowl, remove the black exterior to near the base, at the same time cutting off portions of the hardened mass around the border above, so as to give the whole an irregular surface. Here we have a rude representation of the upper coal group, perhaps as good as any that can be made on a small scale. If this mass be divided vertically in two, the face of each piece will rudely resemble a vertical section across the group from Harrison Co., Ohio, to the eastern portion near the Pennsylvania and West Virginia line.

In Ohio, VIII*a*, VIII*b*, VIII*c* and IX are traced directly to where they have disappeared, while X and XI have been found successively approaching VIII. In Pennsylvania similar conditions exist, but the extensive erosion along the Alleghany slopes prevents us giving so full a presentation as that from Ohio. In each case we find the underlying Pittsburg reaching farther east and west than the immediately overlying beds, and continually approaching the higher ones, until, on both sides of the trough, farther study is cut off by the completeness of erosion.

I am, therefore, compelled to believe that *all the coals of the upper coal group are off-shoots from one continuous marsh, which existed from the beginning of the era to its close, and which in its full extent is now known as the Pittsburg Coal Seam.* During the whole time of formation of the upper coal group the general condition was that of regular subsidence interrupted by longer or shorter intervals of repose. During the time of subsidence the marsh advanced up the sides of the trough, as new

land was continually becoming fitted for its support. During repose, deltas were formed in the bay, and the marsh pushed outward on the newly-formed land. If the period of repose were long enough to permit the bay to be filled up, the marsh would cross to the other side if begun on only one, or, if pushing out from all sides, it would reach the centre. The Pittsburg, Redstone, Sewickly and Waynesburg originated at the east, for there they attain their greatest thickness, while westward they diminish. VIIIc. IX and X of the Ohio section are thickest westward and then eastward, the first barely crossing the Ohio river; the others disappearing before they reach it.

It may be objected that a marsh requires an almost level plain for its existence. Nothing could be more erroneous than such a supposition, for all necessary conditions may exist on a hill-side with not too steep a slope. In Colorado, I found on Arkansas Pass, near the head of the Arkansas river, an immense morass covering the whole surface between the cañon walls, a distance of more than one-fourth of a mile. It reaches for several miles down the cañon, whose floor has a fall of nearly two degrees. This is no petty swamp. To all intents and purposes it is a bottomless morass, almost impassable to mounted stock.

There is every reason to suppose that previous to the upper coal epoch, the conditions were by no means so regular throughout the basin. It is highly probable that just before the beginning of that epoch, the trough was narrowed and the eastern border, at least, much raised. Otherwise it would be difficult to explain why it is that the Pittsburg Coal does not distinctly overlap the lower Barren group. At times during the lower coal epoch the folding process must have been carried on quite energetically, much more so than during the epoch of the upper coals. In the latter there are found no subordinate folds such as are exhibited in the former; such, for example, as occurred previous to the formation of the Kittanning so as to produce the secondary troughs in which that coal lies causing so great variations in the thickness of the interval between it and the Upper Freeport. It seems quite possible, judging from some observations in Ohio, that similar subordinate foldings may have taken place previous to the formation of *Coal III*, the next below the Kittanning.

In view of the facts given in this paper, I feel justified in extending my statement that the Indiana and Appalachian coal-fields were not connected during the lower barren and upper coal epochs, by asserting that there is no reason to suppose that they were ever united north from Kentucky. Whether or not they were united farther toward the south must be determined by others.

Thus far no reference has been made to the trough or basin lying east from the Alleghany Mountains and holding the Barren and the Upper Coal Group. The terrific erosion which this region has suffered, only fragmentary areas of coal remaining, renders the collection of details a work of great difficulty, and few observations exist, which bear upon the question under discussion. This basin and the Great Bituminous Trough

seem to have been branches of one great basin during the Upper Coal epoch. They were separated by a tongue of land tapering southwardly and terminating in West Virginia, not far from the Maryland line. The eastern basin rapidly lost its width, and near the union was quite narrow. The relation between the two basins, as I understand it, is rudely represented in the accompanying figure, in which A, is the western, and B, the eastern, which latter now contains the fragmentary areas of semi-bituminous and anthracite coal.

Whether or not this division of the coal-field existed from the beginning of the period, I am unable to conjecture, as my material respecting the Lower Coal Group is not sufficient. But that it had occurred before the formation of the Barren Group admits of no doubt, as that group has a well-defined saucer-shape in the Great Trough, and thickens eastwardly from the dividing area. In like manner the Upper Coal Group thickens east and west from the same region, the Pittsburg, Redstone and Sewickly Coals being as well marked in the eastern basin as in the western.

The eastern basin, as might have been expected, shows little limestone amid its strata. Surrounded on all sides by highlands, it was fed by numerous streams, which brought down sufficient detritus to render its waters turbid throughout. Its mouth was obliterated topographically by the final convulsions of the Appalachium Revolution, so that its precise position is to be ascertained only by close exploration.

The common basin, below the junction of these branches, was broad and never completely filled with detritus so as to permit the marshes to cross it; certainly at no time after the formation of the Pittsburg in that region. This bed cannot be traced across the basin, owing to the fact that it is deeply concealed in the centre, but the Waynesburg and Brownsville thin out rapidly toward the west, and in West Virginia, have almost disappeared before reaching the disturbed region known as the "Oil-break." Limestones are almost unknown, and for four hundred feet on top, the rocks are entirely sandstone and shale, all the limestones and coals belonging to that horizon being absent.

ON EXFOLIATION OF ROCKS NEAR GETTYSBURG.

By P. Frazer, Jr.

(*Read before the American Philosophical Society, Dec. 4th*, 1874.)

During an examination which I made of the Syenite boulders which compose that part of the battle-field of Gettysburg, called the "Devil's Den," (a collection of great blocks of this rock piled one on another in the wildest confusion and lying about $\frac{1}{3}$ mile west of "Granite Spur" or Little Round Top, the ravine where Vincent's Brigade held their ground so manfully on the afternoon of Thursday, July 2, 1863, and